CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-124

JULY 5, 1982

1. Name and location of fault.

Maacama and related faults, Purdys Gardens to Asti ~~area~~ quadrangles, Mendocino and Sonoma Counties, California (see Fig. 1).

2. Reason for evaluation.

Part of a state-wide program to zone active faults (see Hart, 1980). A preliminary Special Studies Zones (SSZ) map of the Maacama fault has been issued for the Elledge Peak quadrangle, northwest of the study area (California Division of Mines and Geology, 1981). Several faults have already been zoned in the Asti quadrangle (California Division of Mines and Geology, 1976; see Figure 2).

3. List of references.

Blake, M.C., Jr., Smith, J.T., Wentworth, C.M., and Wright, R.H., Preliminary geologic map of western Sonoma County and northernmost Marin County, California: U.S. Geological Survey Open File Map (also, San Francisco Bay Region Environment and Resources Planning Study Basic Data Contribution 12), 5 pl., scale 1:62,500.

Bufe, G., Marks, S.M., Lester, F.W., Ludwin, R.S., and Stickney, M.C., 1980, Seismicity of the Geysers-Clear Lake region, California: U.S. Geological Survey Open-File Report 80-988, 21 p.

California Division of Mines and Geology, 1976, Official map of Special Studies Zones, Asti quadrangle, scale 1:24,000.

California Division of Mines and Geology, 1981, Preliminary map of Special Studies Zones, Elledge Peak quadrangle, scale 1:24,000.

Cartwright Aerial Surveys (?), 1963, Black and white aerial photographs, 1:24,000 scale, series MEN, roll 1, numbers 14 to 22; roll 2, numbers 178 to 181; roll 3, numbers 1 to 11; roll 5, numbers 68 to 75; roll 7, numbers 3 to 11, 124 to 132, and 136 to 145; and, roll 16, numbers 112 to 116 and 119 to 128.

CALIFORNIA DIVISION OF MINES AND GEOLOGY

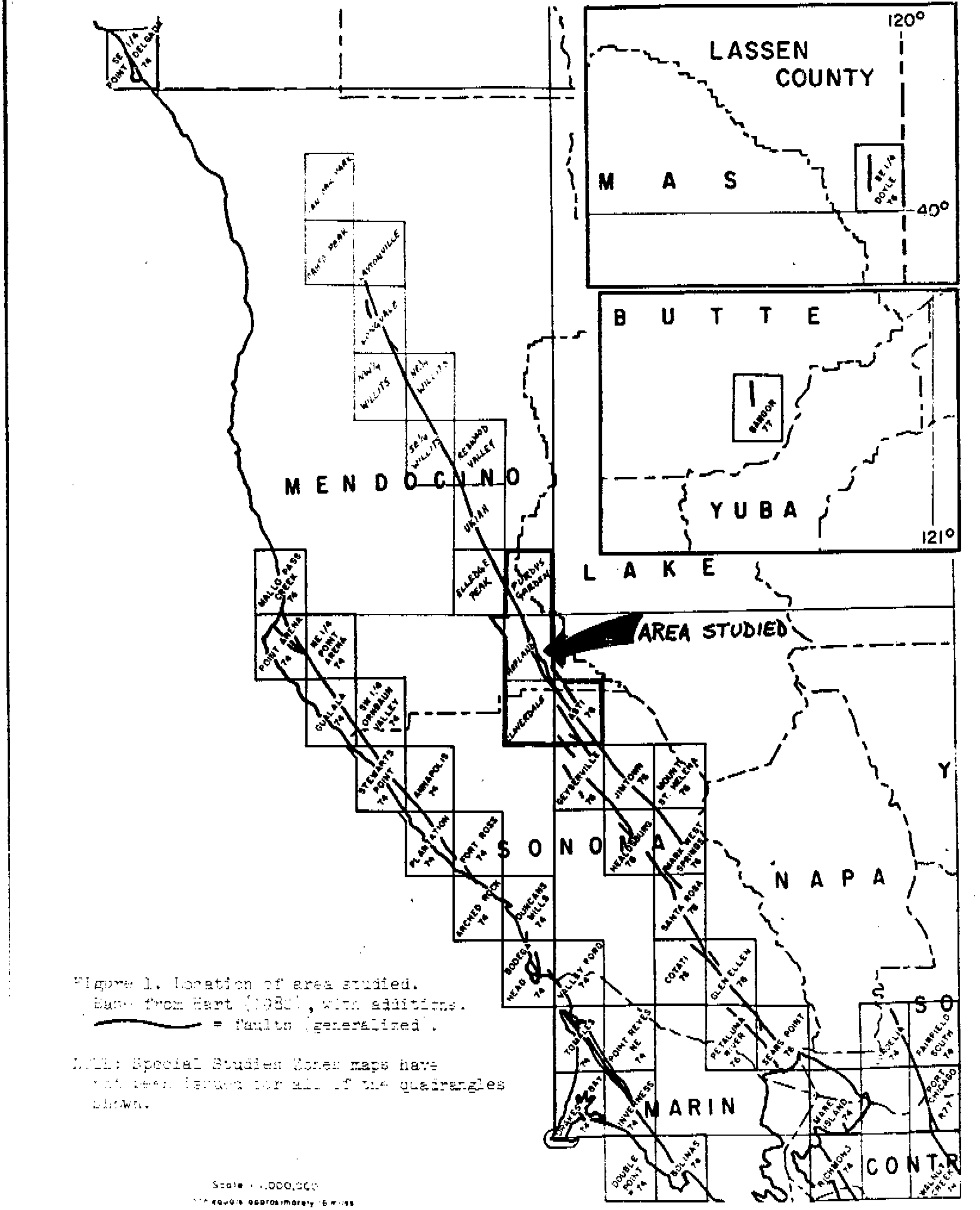

Figure 1. Location of area studied.
Base from Hart (1980), with additions.
——— = faults (generalized).

NOTE: Special Studies Zones maps have not been issued for all of the quadrangles shown.

Cartwright Aerial Surveys, 1965, Bay Area Transportation Study photos, black and white, 1:12,000 scale, series SON, roll 45, numbers 93 to 102, 139 to 148, and 157 to 167; roll 54, numbers 245 to 252; roll 55, numbers 8 to 17, 126 to 135, and 150 to 152; roll 59, numbers 196 to 202; and, roll 72, numbers 60 to 62.

Dames and Moore, 1977, Final Report, Maacama microearthquake survey, in Maacama fault study, Sonoma and Mendocino Counties, Calfornia: U.S. Army Engineers, San Francisco District, Appendix CE-3.

Gealey, W.K., 1951, Geology of the Healdsburg (15-minute) quadrangle, California: California Division of Mines Bulletin 161, p. 7-50, scale 1:62,500.

Harding-Lawson Associates, 1977a, Maacama/Talmage fault study, review of maps and bibliography, in Maacama fault study, Sonoma and Mendocino Counties, California: U.S. Army Corps of Engineers, San Francisco District, Appendix CE-2.

Harding-Lawson Associates, 1977b, Recently active breaks along the Talmage fault zone, Mendocino County, California, in Maacama fault study, Sonoma and Mendocino Counties, California: U.S. Army Corps of Engineers, San Francisco District, Appendix CE-1, scale 1:24,000.

Harsh, P.W., Pampeyan, E.H., and Oakley, J.M., 1978, Creep on the Willits fault, California (abs.): Seismological Society of America Earthquake Notes, v.49, n. 1, p. 22.

Hart, E.W., 1980, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Publication 42.

Herd, D.G., 1978, Intracontinental plate boundary east of Cape Mendocino, California: Geology, v. 6, p. 721-725.

Herd, D.G., and Helley, E.J., 1977, Faults with Quaternary displacement, northwestern San Francisco Bay Region, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-818, Scale 1:125,000.

Herd, D.G., Helley, E.J., and Rogers, B.W., 1977, Map of Quaternary faulting along the southern Maacama fault zone, California: U.S. Geological Survey Open-File Map 77-453, 7 pl., scale 1:24,000.

Huffman, M.E., and Armstrong, C.F., 1978, Field examination of segments of the Healdsburg and Alexander faults with D. Herd, U.S. Geological Survey: California Division of Mines and Geology, unpublished in-house memo of February 1 to Thomas E. Gay, Jr., 8 p.

Huffman, M.E., and Armstrong, C.F., 1980, Geology for planning in Sonoma County: California Division of Mines and Geology Special Report 120, 31p., 8 pl., scale 1:62,500.

Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs, and thermal wells: California Division of Mines and Geology, Geologic Data Map No. 1, scale 1:750,000.

Jennings, C.W., and Strand, R.G., 1960, Ukiah sheet: California Division of Mines, Geologic Map of California, Olaf P. Jenkins Edition, scale 1:250,000.

Knox, R.D., and Huffman, M.E., 1980, Geologic map exclusive of landslides--northern Sonoma County, in Huffman and Armstrong, Geology for planning in Sonoma County: California Division of Mines and Geology Special Report 120, plate 3A, scale 1:62,500.

Marks, S.M., and Bufe, C.G., 1978a, Map showing preliminary hypocenters of earthquakes in the Healdsburg (1:100,000) quadrangle, Lake Berryessa to Clear Lake, California, October 1969-December 1976: U.S. Geological Survey Open-File Report 78-953, 33p.

Marks, S.M., and Bufe, C.G., 1978b, Preliminary hypocenters of earthquakes in the Ukiah and Santa Rosa 1°x2° quadrangles, California, January 1969-June 1977: U.S. Geological Survey Open-File Report 78-126, scale 1:250,000.

Marks, S.M., Ludwin, R.S., Louie, K.B., and Bufe, C.G., 1978, Seismic monitoring the Geysers Geothermal Field, California: U.S. Geological Survey Open-File Report 78-798, 26 p.

McLaughlin, R.J., 1978, Preliminary geologic map and structural sections of the central Mayacamas Mountains and the Geysers Steam Field, Sonoma, Lake, and Mendocino Counties, California: U.S. Geological Survey Open-File Map 78-389, 2 pl., scale 1:24,000.

McNitt, J.R., 1968, Geologic map and section of the Kelseyville (15-minute) quadrangle, Mendocino, Lake, and Sonoma Counties, California: California Division of Mines and Geology Map Sheet 9, scale 1:62,500.

National Aeronautics and Space Administration, 1972, U-2 flight 72-119B, infra-red (false color) aerial photographs (510-900 nm spectral band), approximate scale 1:130,000, frames 1635 to 1643.

Pampeyan, E.H., 1979, Preliminary map showing recency of faulting in coastal north-central California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1070, scale 1:250,000.

Pampeyan, E.H., Harsh, P.W., and Coakley, J.W., 1980, Preliminary map showing recently active breaks along the Maacama fault zone between Laytonville and Hopland, Mendocino County, California: U.S. Geological Survey Open-File Report 80-662.

Pampeyan, E.H., Harsh, P.W., and Coakley, J.W., 1981, Preliminary map showing recently active breaks along the Maacama fault zone between Laytonville and Hopland, Mendocino County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1217.

Radbruch-Hall, D.H., 1978, Gravitational creep of rock masses on slopes, in Voight, B., ed., Rockslides and avalanches, 1, natural phenomena: Developments in geotechnical engineering 14A, Elsevier Scientific Publishing Co., Amsterdam, Chapter 17, p. 607-657.

Simon, R.B., Pampeyan, E.H., and Stover, C.W., 1978, The Willits, California, magnitude 4.8 earthquake of November 22, 1977: U.S. Geological Survey Open-File Report 78-1075.

Smith, T.C., 1981, Maacama fault, area of reported historic rupture: California Division of Mines and Geology Fault Evaluation Report FER-111 (unpublished, on file in the San Francisco District Office).

U.S. Army Corps of Engineers, San Francisco District, 1978, Maacama fault study, Sonoma and Mendocino Counties, California.

U.S. Department of Agriculture, 1952a, Black and white aerial photographs, series CVN, roll 2K, numbers 160 to 162 (1:20,000 scale).

U.S. Department of Agriculture, 1952b, Black and white aerial photographs, series CSH, roll 4K, numbers 75 to 85, roll 6K, numbers 47 to 59; roll 8K, numbers 165 to 170; roll 9K, numbers 149 to 159; and, roll 10K, numbers 47 to 54 (1:20,000 scale).

U.S. Department of Agriculture, 1963, Black and white aerial photographs, series CVN, roll 1DD, numbers 22 to 37, 77 to 81, and 96 to 99; and roll 8DD, numbers 96 to 113, and 145 to 159 (1:20,000 scale).

U.S. Geological Survey, 1973 and 1974, Low-sun, color aerial photographs, series SFB 2, roll 1, numbers 133 to 146; and roll 8, numbers 76 to 85 (1:24,000 scale).

Upp, R.R., 1981, Map of the Maacama fault zone (preliminary) with appendix A, in Holocene activity on the Maacama fault: Stanford University, PhD thesis, work in progress (map filed with CDMG, San Francisco District Office).

4. Summary of available information.

The Maacama fault zone has been described as a series of right-lateral faults along which movement has occurred during Holocene time (Harding-Lawson Associates, 1977b; Pampeyan, et al, 1981; Upp, 1981). Herd (1978) has suggested that the Maacama fault zone is part of a larger system of faults, the Hayward-Lake Mountain fault system, which bounds the Humboldt and North American plates. According to Herd, the Maacama is "connected" to the San Andreas fault system via the Rogers Creek-Healdsburg, Hayward, and Calaveras faults to the south.

Gealey (1951) named the Maacama fault zone. He also cited evidence of recent movement along the Maacama fault near Healdsburg, about 3 miles south of the area addressed herein. The geology of the Hopland and Purdys Gardens quadrangles, as well as that part of the Cloverdale quadrangle within Mendocino County, has not been mapped in detail. Neither the geologic map of the Ukiah sheet (Jennings and

Strand, 1960) nor the fault map of California (Jennings, 1975) show the Maacama fault in the Mendocino County portion of the study area.

As noted earlier, a Special Studies Zones map of the Asti quadrangle has already been issued (California Division of Mines and Geology, 1976). All of the faults zoned were compiled from a map by Knox and Huffman (1980, in press in 1976). Their map did not cover any of the faults in the Mendocino County portion of the quadrangle. They determined that movement has occurred along the Maacama and Chianti faults, as well as two unnamed faults (faults A and B, Fig. 3D) and three branch faults, during the Quaternary. At the time the 1976 maps were issued, faults considered to be potentially active (Quaternary) were zoned. Presently, only those faults that are "sufficiently active (Holocene) and well-defined" are zoned (Hart, 1980).

The geology of the Asti and Highland Springs quadrangles (all part of the Kelseyville 15-minute quadrangle) was mapped by McNitt (1968). He depicted the fault zones as consisting of shorter, arcuate ("scalloped") faults (see Figure 3D). McNitt mapped two zones of faults which partly coincide with the Chianti and Maacama faults of Knox and Huffman (1980). He did not map any faults near faults A and B. Also, he did not depict any faults as cutting Quaternary units.

Blake and others (1971) compiled a geologic map of the Sonoma County part of the study area. They modified McNitt's map slightly, but still did not show any Quaternary units as cut by faults in the study area. They did not map fault A. They do show a fault partly coinciding with fault B as concealed by Quaternary terrace deposits, however. They do not discuss recency of movement along any of these faults.

Knox and Huffman (1980, actually completed in 1972) indicate that they used the map of Blake and others (1971) as their principal source in the Asti quadrangle. Huffman and Armstrong (1980, p. 17-19) indicate that the classification of the segments of the Maacama and Chianti faults as Quaternary was based primarily on Huffman's interpretation of air photos. They state that fault B (possibly part of the Healdsburg fault) cuts Quaternary terrace deposits. They also note that Radbruch-Hall (unpublished) has reported that two fences, located about 1-1/4 miles southeast of Big Sulphur Creek (Asti quadrangle), may have been right-laterally offset by the Maacama fault, but the precise localities were not given.

In an in-house memo, Huffman and Armstrong (1978) provided further information on their evidence for recent movement along fault B (which they call the Alexander Valley fault zone of Gealey, 1950). They cite the existence of faulted terrace gravels, a tilted terrace surface, an eroded fault scarp, two right-laterally deflected drainages, and one fault exposure in Franciscan materials. The purpose of their memo was to summarize the results of a field conference with D. Herd of the U.S.G.S. It is clear from the memo that Huffman and Armstrong differed with Herd as to the age of the most recent faulting: Huffman and Armstrong believed there is evidence of late Pleistocene movement while Herd did not. Huffman and Armstrong concluded that the faulted terrace gravels were late Quaternary in age; Herd and Helley believed these gravels were probably Pliocene or earliest Pleistocene.

Herd and others (1977) delineated Quaternary faults within the Maacama fault zone (see Figures 3C and 3D). Each fault they show is annotated with the geomorphic evidence they used to identify the fault as Quaternary. The overall zone of faulting they depict is about two miles wide, and appears to consist of two narrower zones generally located along the Chianti and Maacama faults of Knox and Huffman. Herd and others also delineated segments of fault A, and some other faults to the north and west of fault A. They chose not to connect these individual faults, the longest of which is about 6000 feet long. They also delineated some of the larger landslides. Several of the geomorphic features they cite are permissive of Holocene or Quaternary faulting (e.g., saddles, trenches, benches, and scarps). They report sag ponds are present along the Maacama fault in a few places, and also along fault C (Fig. 3D). They do not depict a Quaternary fault near fault B.

In the area studied, the map of Herd and Helley (1977) is essentially unchanged from Herd and others (1977). Herd and Helley indicate that all the faults they depict in the Asti and Cloverdale quadrangles are Pleistocene in age. Their legend notes that Pleistocene units (10,000 to 2,000,000 years old) are offset, but Holocene units remain unbroken by these faults.

Radbruch-Hall (1978), in discussing downslope movement processes, cited the existence of massive landslides between Hopland and Cloverdale. She noted, "In this area the entire ridge that extends for approximately 10 km on the northeast side of the Russian River, between Big Sulphur Creek (Fig. 3D) and Pieta Creek (Fig. 3B) is covered with active landslide deposits." She attributes the features cited along fault A by Herd ~~of Helley~~ and others (1977) to this downslope movement. She further states, "Although at least one active fault is known within a few kilometers of the ridge, there is no evidence that it extends through the ridge top" (Radbruch-Hall, p. 634-636).

In January, 1978, the U.S. Army Corps of Engineers released a study of the Maacama fault. Within the Corps' report were three other reports (Dames and Moore, 1977 (see section 6); Harding-Lawson Associates, 1977a and 1977b). The primary objective of the Corps' study and the Harding-Lawson study was to determine the overall length of the active Maacama fault so that the maximum credible earthquake could be estimated. To delineate the Maacama fault (which they called the Talmage fault), Harding-Lawson Associates primarily relied on aerial photo interpretation, literature research, and limited field reconnaisance. In the Hopland and Purdys Gardens quadrangles (Fig. 3A and 3B), they depicted the Maacama fault zone in a generalized fashion, noting only troughs, closed depressions, scarps, and springs. The faults they show mostly appear "ruler straight", and form a zone less than 6000 feet wide. In the southern part of the study area they relied on the work of Herd and Helley (1977).

After the Harding-Lawson Associates and Dames and Moore studies were completed, a 4.8-magnitude earthquake occurred near Willits. During the post-earthquake investigations, Harsh detected evidence of fault creep in downtown Willits, northwest of the area studied herein (Simon and others, 1978). Subsequently, quite convincing evidence of fault creep has been documented near Ukiah, as well as in Willits (Harsh and others, 1978; Pampeyan and others, 1980 & 1981; Upp, 1981; and Smith, 1981). Smith (1981, supplement) has reported evidence of fault creep in the Elledge Peak quadrangle about 4 miles northwest of the faults shown in Fig. 3A.

McLaughlin (1978) completed a detailed geologic map of part of the Geysers geothermal area. Although he did not discuss or classify the faults, he does show closed depressions and fault scarps. Only part of the Maacama fault and fault A were within the area he studied. He depicts fault A as bordering Quaternary terrace deposits in one location in the study area (Fig. 3D).*

Pampeyan's (1979) fault classification map covers all of the study area south of the 39th Parallel. In the Hopland quadrangle, he shows six Holocene faults, all of which are shown on a later map by Pampeyan and others (1980 and 1981, discussed below). Pampeyan depicts one of these Holocene faults as extending through the Highland Springs quadrangle into the area of fault C in the Asti quad-

* McLaughlin (oral communication, 7/2/82) described this contact as terrace deposits which were deposited along a fault scarp and subsequently sheared. He described the exposure as problematic, noting that he felt it supports late Quaternary displacement along this fault. [His legend cites terrace deposits as Holocene in age, but he noted the C14 date (7000 ybp) on these deposits now appears to be erroneously young].

rangle (Fig. 3D). Within the Asti quadrangle, he shows only the Maacama fault and fault C as Holocene in age. He concludes that the Chianti fault and fault B are late Quaternary and that fault A is Quaternary. He also concludes that the westerly branch of the Chianti fault, currently zoned (CDMG, 1976; see Fig. 2), is of unclassified age (no evidence to suggest movement has occurred along it during the last 12 million years). Two other faults east of the Maacama fault are shown as late Quaternary in age; all other faults are shown as lacking evidence of Quaternary movement.

Pampeyan and others (1980 and 1981, the two of which are identical) have delineated the Maacama fault zone in and beyond the northern part of the area studied (Fig. 3A and 3B). They show "lineaments and features interpreted to be the result of recent (Holocene) movements within the Maacama fault zone". Their map is annotated somewhat, but they state (p. 5) that only "especially clear" features are noted. Some of the faults they show lack any annotations. In the area studied, they show a zone of faults about two to five miles wide (see Figures 3A and 3B). They state (p. 16) that the Talmage fault (their name for this segment of the Maacama fault) appears to die out between the U.C. (Hopland) Field Station (Fig. 3A) and McDowell Valley (Fig. 3B). North of this area, they report the fault is well defined. To the south, they note there are fewer geomorphic features indicative of recent movement. They also report "...some cracks and a subtle west-facing scarp in the pavement of California State Highway 175 (Highway 16 on Fig. 3B) and (an) adjacent side road... in line with a fault contact in the roadcut...", but that the cause of these features has not been determined. In one paragraph discussing the faults along Parsons Creek (Fig. 3A) and the Russian River (Fig. 3B), they cite a "paucity of ephemeral fault-break features". They conclude that these latter faults may not have been active since the Pleistocene.

Upp (1981) depicts a fault zone up to 4 miles wide in the area studied (Fig. 3A, 3B, and 3C). He attempted not only to identify Holocene faults, but also indicate how certain he was that movement had occurred along each fault strand during the Holocene. He also noted the geomorphic and other evidence he used to determine recency and location of such faults. Upp notes (Appendix A) that many landslides have masked the location of the Maacama fault south of McDowell Valley but that the prominent sidehill valley in Section 13, T ~~13~~ 12 N, R 11 W (Fig. 3B) is certainly the result of Holocene movement. Similarly, he believes one of the traces delineated in section 9, T13N, R 11W (Fig. 3B) and one located in and northwest of Section 30, T 14 N, R 11 W (Fig. 3A) are certainly Holocene faults. In a general statement, he attributes many of the other features he depicts to non-tectonic causes (bedding & landslides) or pre-Holocene faulting.

5. Air photo interpretation.

USDA (1952a; 1952b; 1963), U.S. Geological Survey (1973 and 1974), Cartwright Aerial Surveys (1963; 1965) and NASA (1972) aerial photographs were interpreted for the purposes of verifying and supplementing the evidence of Holocene movement along the faults mapped by others (see section 4). Clear evidence of recent (Holocene) faulting was observed only along a fairly narrow zone of faults depicted on Figures 4A, 4B, 4C, and 4D. Locally this zone is almost 1 mile wide, primarily where complicated by landslide movement or lateral spreading.

Much of the study area consists of Franciscan bedrock, which includes resistant bodies of greenstone and sandstone (as well as other rock types) and classic Franciscan melange. The main active fault zone mostly traverses landslide-mantled melange terrain. In several places, either the faults have not propogated through the landslide deposits or the diagnostic geomorphic features indicative of Holocene faulting have been obliterated by downslope movement. Even so, features suggestive of Holocene fault movement are sometimes present in the landslide areas, although some of these features may have been created wholly or partly by landslide movement.

In and northwest of Section 30, T 14 N, R 11 W (Fig. 4A) , the Maacama fault is very well-defined by abundant geomorphic features indicative of probable Holocene strike-slip displacement (see Fig. 4A). Hagan Lake, to the south, may be either the result of fault movement, landslide movement, or both. Between Section 30 and Hagan Lake the location of the fault is less obvious and it appears the zone may be slightly more complex. South of Hagan Lake the fault is obscured by massive landslide deposits.

Between Parsons Creek (Fig. 4A) and State Highway 16 (Fig. 4B) are several closed depressions which indicate the fault takes a rather curious bend. It appears the course of the fault may be controlled by bedding or older faults in Section 9, and in Sections 15 and 16 is not very well displayed on the photos interpreted. These features may also have, at least in part, resulted from downslope movement.

South of State Highway 16 (Fig. 4B) there appears to be a large shutter ridge which once closed off the McDowell Valley. Several features permissive of recent faulting (e.g., linear drainages and broadly deflected drainages) are present on the eastern side of this ridge. Several ponds and reservoirs are also present in McDowell Valley, but no clear, well-defined fault features align with these depressions. Along the west side of the shutter ridge, however, is a series of small drainages that are right-laterally deflected systematically along one or, in some places, two lines. A northeast-trending scarp (in sections 21 and 22) appears to connect this western zone with the northward continuation of the eastern zone, suggesting that the zone of active faulting may have shifted westward in very recent times.

The active fault is fairly well defined between Pieta Creek (Fig. 4B) and the southern end of the shutter ridge described above. South of Pieta Creek, the fault crosses an area of large, complex landslides. Several of the features shown between Pieta Creek and Big Sulphur Creek (see Figs. 4B, 4C, and 4D) may be fortuitously aligned landslide features. However, many of these features may have resulted from fault movement (in situ) or have been displaced downslope after faulting. Four aligned closed depressions in Sections 12 and 13 (T 12 N, R 11 W, Fig. 4B), probably are fault-produced features or are ridge-top trenches and uphill-facing scarps of probable gravitational origin (see Radbruch-Hall, 1978).

The precise location of the active fault is mostly obscured by landslides or masked by the Franciscan terrain in the Cloverdale and northern Asti quadrangles (Fig. 4C and 4D). Some features suggestive of recent faulting along the main Maacama fault and fault A are present in the Asti quadrangle just south of Mendocino County. Considering the characteristics of the Maacama fault to the north of the Cloverdale quadrangle and to the south of Big Sulphur Creek, it is likely that the active fault traverses this area (mostly concealed by landslide deposits) as shown on Fig. 5B.

South of Big Sulphur Creek, two possible fault zones are plotted on Fig. 4D. The eastern zone is marked by numerous fault-produced geomorphic features and is almost certainly Holocene-active. Features along the western zone are permissive of Holocene activity but most probably have resulted from differential erosion along an old fault. This western zone of features could only be followed for about 2-1/2 miles, but is aligned with the broad deflection of Big Sulphur Creek to the north.

All of the features and trends noted by Upp (1981), Pampeyan, et al (1980 & 1981) and Harding-Lawson Associates were checked and selectively annotated in red on Figures 3A ~~and 3B~~. Some of these features were verified (see Figs. 4A and

4B) and have already been briefly discussed. All other features they note appear to be the result of landslide movement, differential erosion, or other non-tectonic causes. Many of the "fault" trends do not appear to be the simple, throughgoing faults they depict, and lack good evidence of holocene movement.

All of the faults and features noted by various workers in the Cloverdale and Asti quadrangles (see Figs. 3C and 3D) were also checked (on aerial photos). As noted above and on Figs. 4C and 4D, some faults were verified and appear to be sufficiently active and well-defined. All other faults of other workers (e.g., Herd, et al, 1977; Knox and Huffman, 1980; and McLaughlin, 1978) do not appear to be sufficiently active or well-defined, or both. No clear geomorphic evidence was noted that would support the existence of a Holocene fault near Dutcher Creek Road (SW corner of the Asti quadrangle), although a pre-Holocene fault is evident in exposures and on the photos interpreted. Neither could this investigator verify the existance of a recently active fault in Sections 33 and 34 (T 12 N, R 10 W) and 2, 3, and 11 (T 11 N, R 10 W) as mapped by Herd, et al (1977) (see Fig. 3D).

6. Field Investigations.

A reconnaissance of the study area was made primarily to field check selected areas for fault creep. No such evidence was found. The cracks reported by Pampeyan, et al (1980; 1981) near State Highway 16 (see Fig. 3B) appear to be the result of slope failures. As noted in FER-111 (Smith, 1981), the fault exposure reported by Pampeyan, et al, adjacent to State Highway 16 was obscured by landslide debris.

Hart and Rice (personal communications, August, 1981, based on observations made some years ago) both reported observing that the pavement of Dutcher Creek Road was cracked and two of the painted lines appeared to be left-laterally offset. On trend, a fault is exposed in the adjacent road cut. Hart also stated that not all of the painted lines were offset, and that he was not sure fault creep had caused the disturbances. The site was field checked in August, 1981. The pavement on trend with the exposed fault has been abraded by road maintenance crews, and the offsets of the painted lines could no longer be observed. The roadway is severely cracked for several hundred feet on either side of the fault exposure. The roadcuts have failed in several places. All of the observed damage appears to be the result of highly expansive materials. Nowhere were any left-stepping, en echelon fractures indicative of right-lateral strike-slip fault movement observed.

7. Seismicity.

The seismicity of the study area has been well-documented only since about 1972 (Marks, et al, 1978). In 1977, Dames and Moore conducted a detailed study of the seismicity along the Maacama fault. They state that the apparent lack of recorded earthquakes in the area is probably related more to the detection capabilities of the U.S. Geological Survey and University of California seismic networks than to the lack of seismicity. Dames & Moore directed their efforts at detecting microearthquakes along the Maacama fault zone. While the seismographic record from 1906 to 1976 does not clearly show a zone of greater seismic activity along the Maacama fault, the Dames and Moore microseismic survey, conducted over a 72-day period ending September 23, 1977, does appear to document seismic activity associated with the Maacama fault. The zone of activity seems to be centered about 2 to 3 miles east of the mapped trace. Dames and Moore reported that the fault plane solutions were consistent with right-lateral, strike-slip movement. Marks and Bufe (1978a; 1978b) and Bufe, et al (1980) have documented that this zone of microseismicity extends southeastward to beyond Santa Rosa.

A 4.8 earthquake occurred near Willits, to the north, on November 22, 1977, just after the Dames and Moore study concluded. Simon, et al (1978) suggested, based on UC Berkeley data, that this epicenter was located about 9 miles east of the Maacama fault; however, this earthquake may have occurred on the Maacama fault since creep was reported in Willits shortly after that earthquake (Harsh, et al., 1978)

8. Conclusions.

The presence of geomorphic features indicative of Holocene movement along a narrow, fairly continuous zone of locally well-defined faults indicates that the Maacama fault is active (Holocene). The fault is locally very well-defined, especially near Morrison Creek (Fig. 4A), in some places south of State Highway 16 (Fig. 4B), and in the southern part of the Asti quadrangle (Fig. 4D). Other segments of the fault are locally obscured by landslides, notable just north of the county line (Fig. 4C) and north of Big Sulphur Creek (Fig. 4D).

Numerous other active or potentially active faults have been mapped by various workers (see item 4), but there is little evidence to indicate that they are active and most are not well-defined. Of the faults currently zoned on the Asti quadrangle, it appears the unnamed fault (fault B) in the southwestern corner of the Asti quadrangle is not recently active based largely on the lack of ephemeral, fault-produced geomorphic features. The damage reported as evidence of possible fault creep does not appear to be tectonically caused. Data to support Holocene movement of fault A is equivocal, at best, especially since geomorphic evidence of recent movement is lacking. The Chianti fault, also currently zoned, appears to be fairly well-defined in part and not well-defined elsewhere, and lacks clear evidence of Holocene displacement.

9. Recommendations:

Based on the information summarized herein, the Maacama fault should be zoned approximately as shown on Figures 5A and 5B. All other faults currently zoned should be deleted. The following references should be cited on the revised SSZ maps (*denotes primary references used):

Purdys Gardens and Hopland quadrangles: Pampeyan, et al (1981): Upp (1981); and this FER*.

Asti quadrangle: McLaughlin (1978)*; and this FER*.

10. Investigating geologist; date:

Theodore C. Smith

THEODORE C. SMITH
Associate Geologist
RG 3445, CEG 1029

Date: July 5, 1982

TCS/smr

"I generally concur with the observations, conclusions and recommendations, but have added additional comments in pencil to Figures 4 (A, B, C, D) and 5 (A, B). Other minor adjustments may need to be made in order to be consistent with the zoning decisions elsewhere along the Maadama fault zone.

(SGD) EARL W. HART
7/6/82 EWH